Preface

This monograph is intended for engineers and scientists interested in wind energy resources and its applications on power systems. The monograph focuses on the reactive power management of power networks with huge amount of wind energy generation. Nowadays, wind energy has widely proved to be one of the most competitive and efficient renewable energy sources and, as a result, its use is indeed continuously increasing. As an example, in June 2010, the total installed wind energy capacity around the world was 175,000 MW. The incorporation of wind energy units into distribution networks not only modifies power flows but also, in some situations, could result in under- or over-voltage on specific points of the network. Furthermore, it would be able to increase the cases of power quality problems and produce any type of alterations regarding voltage stability.

Reactive power compensation systems are presented as a good alternative that aims to alleviate problems related to voltage stability. Reactive power planning in large power systems has become a particularly important task in recent years since it is necessary to develop new techniques to solve any problem that may arise.

The process of high wind energy penetration requires an impact analysis of this new technology applied to power systems. In these terms, some countries have already developed grid codes in order to establish the requirements of wind farms into power networks. Moreover, power network planning with high wind energy penetration requires the definition of several factors, such as the best technology to be used, the optimal number of units to be connected and the optimal size to be chosen.

Currently, a variable-speed wind turbine connected to power systems by means of power electronic converters has the ability to supply reactive power to power systems. This capability allows wind turbines to participate in ancillary services as synchronous generators. However, there are few works focusing on the participation of variable-speed wind turbines in reactive power ancillary services.

A revision of the Grid code requirements in different countries is shown in Chap. 1. Chapter 2 contains a description of the reactive power capability from FACTS devices such as Static Var Compensators (SVC); Static Synchronous compensator (STATCOM) and Dynamic Voltage Restorer (DVR). A brief description of wind

generators is given in Chap. 3 where the reactive power capability of fixed-speed wind farms, double-fed induction generators and full-power converter technology is analysed.

The usually applied optimization strategies in power systems for reactive power management analysis are described in Chap. 4. Moreover, metaheuristic techniques have come up to be a good alternative to resolve the problem related to optimal management of reactive power, which involves operation, location and optimal size of these units. Among these techniques, genetic algorithms stand out because of their speed of calculation and simplicity. The proposed optimization strategies will enable not only to determine the optimal location of the reactive power compensation units but also the management of the reactive power injection to fulfill the needs of different load and generation scenarios in power systems.

Chapter 5 provides an overview of the voltage stability problem, which turns out to be even more critical in the power networks which are heavily loaded, are faulted, or have insufficient reactive power supply. As a solution, it is shown that wind energy sources coupled to the network through power converters offer the ability to provide a very fast, dynamic Var injection, and thus their optimal allocation in the power network could alleviate voltage instability or even prevent voltage collapse.

Finally, the benefits associated with the optimal implementation of reactive power management in power systems with high wind energy penetration are analysed in Chap. 6.

In all the above-mentioned chapters, the validity of the designs is corroborated by using simulations in realistic power networks in terms of network security standards.

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Amaris, H.; Alonso, M.; Alvarez Ortega, C.

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